Claims

What is claimed is:

1. A method for determining an opacity value of an emission plume the method comprising the steps of:

directing a beam comprising at least two different wavelengths of electromagnetic radiation through an emission plume;

detecting the beam after the beam has passed through the emission plume;

determining a change in intensity of the beam for each of the at least two different wavelengths of electromagnetic radiation;

comparing the change in intensity for a predetermined number of measurements of the at least two different wavelengths of electromagnetic radiation, and, if the change in intensity for the predetermined number of measurements of the at least two different wavelengths of electromagnetic radiation is substantially equivalent,

determining an opacity value related to the change in intensity for the predetermined number of measurements of the at least two different wavelengths of electromagnetic radiation.

2. The method of claim 1, wherein the beam further comprises:

a first wavelength that is substantially in the infrared spectrum;

a second wavelength that is substantially in the visible spectrum; and

a third wavelength that is substantially in the ultra-violet spectrum.

3. A method for measuring opacity using a remote emission sensing system that measures on-road vehicle exhaust emissions, the method comprising:

directing at least two different wavelengths of electromagnetic radiation through an exhaust emission plume;

detecting the at least two wavelengths of electromagnetic radiation after they pass through the exhaust emission plume;

determining the relative concentration of a vehicle exhaust constituent present in the exhaust emission plume;

determining a change in intensity for each of the at least two different wavelengths of electromagnetic radiation;

correlating the change in intensity for each of the at least two different wavelengths of electromagnetic radiation to the determined relative concentration of the vehicle exhaust constituent;

registering a valid opacity value for each of the at least two different wavelengths of electromagnetic radiation that substantially correlate to the determined relative concentration of the vehicle exhaust constituent;

comparing the change in intensity for a predetermined number of the at least two different wavelengths of electromagnetic radiation and, if the change in intensity for the predetermined number of the at least two different wavelengths of electromagnetic radiation is substantially equivalent,

calculating a reported opacity value proportional to an average of the valid opacity values.

4. The method of claim 3, further comprising:

directing a third different wavelength of electromagnetic radiation through the exhaust emission plume.

5. The method of claim 4 wherein,

a first of the at least two different wavelengths of electromagnetic radiation comprises a wavelength that is substantially in the infrared spectrum;

a second of the at least two different wavelengths of electromagnetic radiation comprises a wavelength that is substantially in the visible spectrum; and

the third different wavelength of electromagnetic radiation comprises a wavelength that is substantially in the ultra-violet spectrum.

6. A system for measuring an opacity value for an exhaust emission plume, the system comprising:

a source of electromagnetic radiation that is directed through an exhaust emission plume;

a detector that detects the electromagnetic radiation and outputs a detector signal proportional to the detected electromagnetic radiation; and

a processor that receives the detector signal and calculates an opacity value for the exhaust plume based, at least in part, upon the detector signal.

7. The system of claim 6 wherein the source of electromagnetic radiation further comprises:

one or more sources that emit electromagnetic radiation in a first wavelength region, a second wavelength region and a third wavelength region.

8. The system of claim 7 wherein

the first wavelength region is substantially in the infrared region;

the second wavelength region is substantially in the visible region; and

the third wavelength region is substantially in the ultra-violet region.

9. The system of claim 7 wherein

the detector is enabled to detect electromagnetic radiation in each of the first, second and third wavelength regions and outputs a signal proportional to a detected intensity at each of the first, second and third wavelength regions; and

the processor further comprises:

a comparison module that compares the detected intensity of each of the first, second and third wavelength regions.

10. The system of claim 9 wherein

the processor further comprises:

an opacity determination module that determines an opacity value proportional to the change in intensity for the detected intensity of each of the first, second and third wavelength regions.

11. A remote sensing system for measuring opacity of a vehicle exhaust plume the system comprising:

a source that directs at least two different wavelengths of electromagnetic radiation through an exhaust emission plume;

a detector that detects the at least two different wavelengths of electromagnetic radiation and produces an output signal; and

a processor comprising:

a relative concentration module that determines a relative concentration of a vehicle exhaust constituent present in the exhaust emission plume;

a change in intensity module that determines a change in intensity for the at least two different wavelengths based, at least in part, upon the output signal;

a correlation module that correlates the change in intensity for the at least two different wavelengths to the relative concentration of the vehicle exhaust constituent and registers a valid opacity value for each of the at least two different wavelengths that substantially correlate to the determined relative concentration of the vehicle exhaust constituent; and

a calculation module that compares the change in intensity for a predetermined number of the at least two different wavelengths of electromagnetic radiation and, if the change in intensity for the predetermined number of the at least two different wavelengths is substantially equivalent, calculates a reported opacity value proportional to the average of the valid opacity values.

12. The system of claim 11 further comprising:

a source of electromagnetic radiation comprising a third different wavelength.

13. The system of claim 12 wherein,

a first of the at least two different wavelengths of electromagnetic radiation comprises a wavelength that is substantially in the infrared spectrum;

a second of the at least two different wavelengths of electromagnetic radiation comprises a wavelength that is substantially in the visible spectrum; and

the third different wavelength comprises a wavelength that is substantially in the ultra-violet spectrum.

14. A method for calculating an opacity value for an exhaust emission plume, the method comprising:

obtaining an measurement of an exhaust constituent amount (n) in a spatial volume of an exhaust emission plume;

directing a beam of substantially monochromatic electromagnetic radiation substantially through the spatial volume of an exhaust emission plume;

measuring a transmittance (T) of the beam of substantially monochromatic electromagnetic radiation;

calculating an opacity value (K_s) proportional to the relation

$$K_s = \frac{\ln\left(\frac{1}{T}\right)}{n}.$$

15. The method of claim 14 wherein the measurement of an exhaust constituent amount comprises a measurement of an amount of carbon dioxide (n_{CO2}).

16. The method of claim 14 wherein the beam of substantially monochromatic electromagnetic radiation comprises:

a beam of substantially ultra-violet radiation.

17. A system for determining an opacity value for an exhaust emission plume, the system comprising:

an exhaust constituent amount measuring system that measures an exhaust constituent amount (n) in a spatial volume of an exhaust emission plume;

a source of substantially monochromatic radiation capable of forming a beam of radiation;

a transmittance measuring system that measures a transmittance (T) of the beam of radiation; and

a processor further comprising:

an opacity calculation module that calculates an opacity value (K_s) according to the relation

$$K_s = \frac{\ln\left(\frac{1}{T}\right)}{n}.$$

18. The system of claim 17 wherein the source of substantially monochromatic radiation produces ultra-violet radiation.

19. The system of claim 17 wherein the exhaust constituent amount measuring system measures an amount of carbon dioxide (n_{CO2}).

20. The system of claim 17 wherein the exhaust constituent amount measuring system measures an amount proportional to the sum carbon monoxide and carbon dioxide ($n_{CO} + n_{CO2}$)